1992

Grain Prices In Zhili, 1738-1910: A Preliminary Study

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Grain Prices in Zhili Province, 1736–1911: A Preliminary Study

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The recent availability of grain price data for the Qing period now provides historians with an unprecedented opportunity to develop their understanding of the agricultural economy of every region of China. This study represents a preliminary attempt to apply the Qing period grain price data to an ongoing study of agriculture, food crises, natural disasters, and government relief in North China.[1] This rich series of data allows us to gain insight into the nature of the agricultural regime in the North, the long-term trends in the agricultural economy, the nature of short-term changes, the economic and social impact of natural disasters, and the extent of market integration and development. Because this is a first attempt, the methodology employed is exploratory, and the conclusions drawn should be regarded as tentative. In the future, completion of the data set and refinement of the methodology may

Many people have given me invaluable assistance with this project. In particular I would like to acknowledge the substantial contribution made by Keith Head (Swarthmore, '86), who helped analyze these data during the summers of 1986 and 1987 with the support of the Joel Dean Fund of Swarthmore College. Gudmund Iversen, Professor of Statistics at Swarthmore, has been generous with his time and expertise. A number of other Swarthmore colleagues have also generously offered guidance or assistance: John Boccio, Stefano Fenoaltea, Robinson Hollister, Jody Ann Malsbury, Frederic Pryor, F. M. Scherer, and Leah Smith. Several Swarthmore students have diligently assisted in the entering of data or with graphics: Patrick Awuah, Donald McMinn, Karen Neumer, Bonnie Spear, and Paul Talcott. I have benefited greatly from the comments of both economists and historians who participated in the Workshop and Conference on Economic Methods for Chinese Historical Research, held in January 1987 in Honolulu, Hawaii, and January 1988 in Oracle, Arizona.

1. This essay is part of a projected book on this region, *Flood and Famine in China: State Policy and Ecological Disaster in the Hai River Basin, 1690s–1990s*. The present study should be regarded as preliminary in part because the set of grain price data that I have collected thus far, though extensive, is still incomplete.

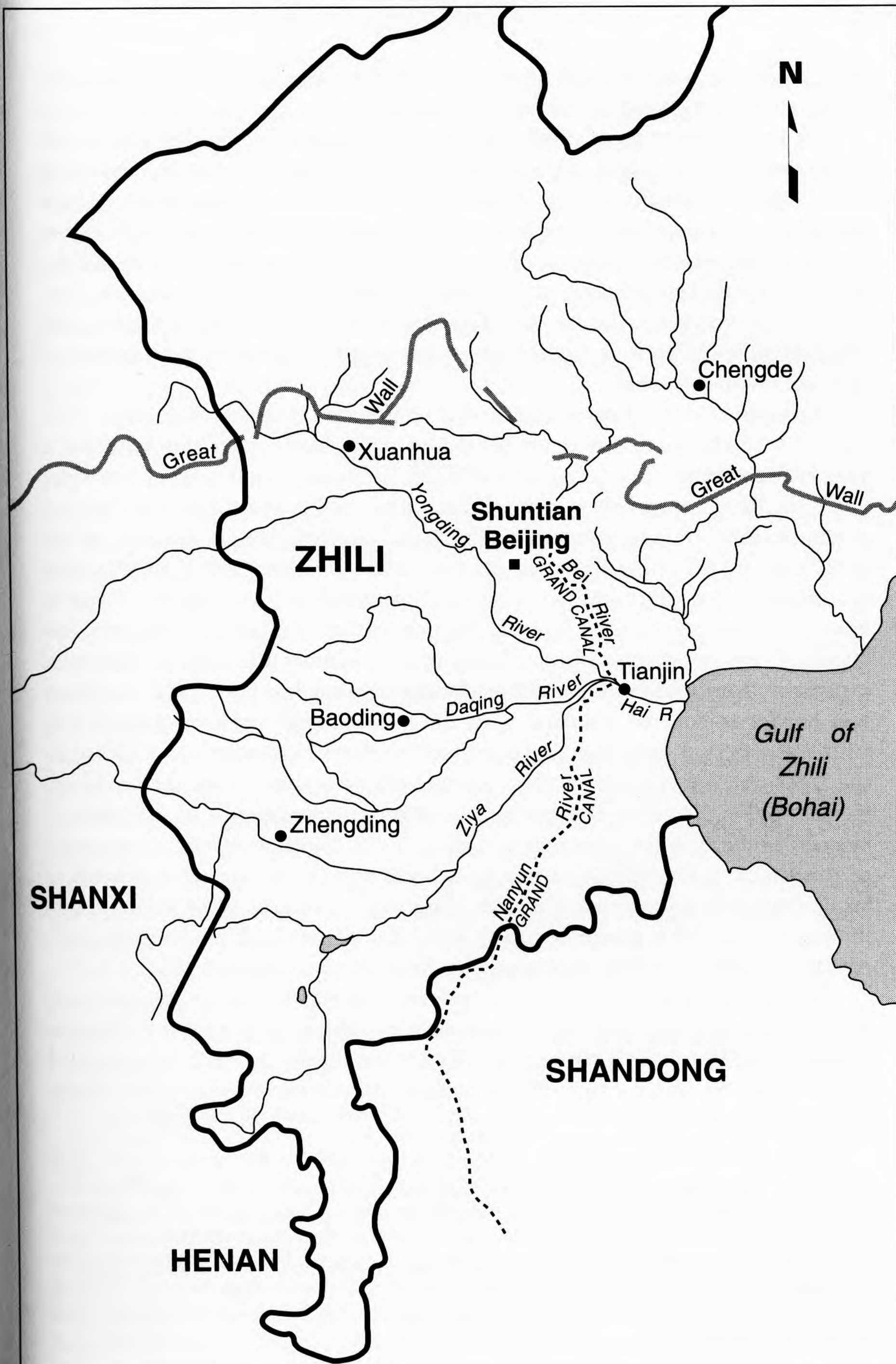
alter the conclusions, but in the interim these tentative results will, hopefully, generate some hypotheses for further analysis and research.

North China is the birthplace of China's civilization and the location of its imperial capitals throughout most of its history. Yet in recent centuries North China has also suffered unfavorable natural conditions and economic hardships. Unlike the fertile rice-growing regions of South China, the North practices mixed cultivation of dry-land grains under climatic conditions that have made the fate of each year's crop extremely uncertain.

Zhili Province (roughly equivalent to modern-day Hebei Province), the subject of this article, best embodies these contradictory characteristics. As the site of the imperial capital of Beijing since the thirteenth century, Zhili had economic advantages that derived more from its political centrality than from its natural resources. The emperors of the Qing dynasty (1644–1911), like their predecessors of the Yuan and Ming dynasties, sought to bring some of the material benefits of the South to the North. The Grand Canal was maintained specifically for the purpose of transporting rice and other products from the South to the capital. The grain tribute was intended to feed the court and officialdom, but it had the unintended consequence of linking the economies of North and South. It was the only significant North-South thoroughfare until railroads were introduced in the twentieth century. The strategic importance of Beijing also dictated that the court pay special attention to stocking both civilian and military granaries in the capital area as well as to the maintenance of the waterways in the province.

The care and protection of the Qing imperial court and its retainers took place, however, in the context of natural conditions that seem to have deteriorated through the centuries. The river system in particular has been a source of ongoing headaches. In ancient times many rivers flowed down from the Taihang mountain range, which forms a boundary between Zhili and Shanxi, its neighbor to the west. But the construction of the Yuan dynasty Grand Canal severed the normal channels of these waterways to the ocean, forcing them to flow into the canal itself. From that time on, the only outlet of five major waterways—the Bei, Yongding, Daqing, Ziya, and Nanyun rivers—was a single, short channel flowing from Tianjin to the ocean, known as the Hai River. This entire river system is known today as the Hai River Basin and is one of China's major river conservancy concerns.

Although smaller in scale, the Hai River Basin has many of the same characteristics as the larger Yellow River Basin, with which it became more closely linked after the Yellow River changed course in the 1850s to the north side of Shandong peninsula. Both have extremely shallow beds, which over the centuries have risen with increased siltation. In recent times deforestation in the mountains has accelerated the silting process. The control of these rivers requires intensive dredging, diking, and other engineering efforts. Over time, the vulnerability of these rivers to flooding has greatly increased, as has



Map 2.1. Zhili Province in the Qing Period. Adapted from the end-map in *Qingdai Haihe Luanhe honglao dang'an shiliao* (Beijing, 1981).

their tendency to waterlog the soil, particularly given the flat, even concave, topography of the land in their lower reaches.

The uneven pattern of rainfall in North China further contributes to the danger of flooding. Most of the annual rainfall in the region is concentrated in the summer months of July, August, and September. It does not take very much rain to cause the rivers to overflow. Ironically the danger of flooding occurs in the context of the overall scarcity of rainfall in the North. As a rule, drought is a more pervasive and potentially serious problem than flood, but it is the river system, the nature of the topography, and the soil that make flooding such a frequent danger and waterlogging a near-chronic condition in some low-lying areas.

Throughout the Qing dynasty, the court and bureaucracy paid close attention to the dual threats of flood and drought. In part this reflected a general bureaucratic concern with disaster prevention that was empirewide, but Zhili Province clearly posed special problems because of its political importance. The bureaucratic record reflects the tremendous concern of the court and officials with river conservancy and with the stocking of granaries to guard against shortages. In the eighteenth century these efforts appear to have been quite successful in both the prevention and relief of famines, but vigilance was constantly required. During the nineteenth century, however, especially from mid-century, either the efforts were less successful or nature was harder to control. Starting with the great drought of the 1870s, North China was periodically beset by one disaster after another until the 1960s. In the 1890s there was hardly a year in which flooding did not occur somewhere in this region. In 1917 there was a massive, provincewide flood, followed closely by the North China drought of 1920–21. Since 1949 the government of the People's Republic has assigned high priority to the management of land and water resources in the area. The sinking of tube wells for irrigation in many parts of the province has proceeded together with engineering projects to prevent the recurrence of major floods, such as that of 1963.

Despite this somewhat unstable context, North China in general, and Zhili/Hebei in particular, have been able to sustain a large population increase in the last two centuries. In 1749 the population of Zhili was reported to be about 14 million.[2] In 1790 the population was recorded as 23.5 million.

2. This 1749 figure almost certainly represents an underestimate. Before the *baojia* system of population registration was reformed in 1775, underestimation was common. See Ping-ti Ho, *Studies on the Population of China, 1368–1953* (Cambridge, Mass., 1959), pp. 36–48. Ho concludes that the population figures of the 1741–1775 period were on the average underestimated by 20 percent. By that formula, Zhili's 1749 population may have been close to 16.8 million. Zhili did not submit its first detailed population return under the reformed system until 1778. If Zhili's population was 16.8 million in 1749 and 23.5 million in 1790, it experienced a 40 percent increase over 41 years.

The rate of growth slackened in the next half-century; in 1850 the reported population was only 23.4 million. In 1933 Hebei's population was about 38.4 million, and in 1953, 46.6 million. In 1982 the population of the province, together with that of the independent municipalities of Beijing and Tianjin, was about 70 million.[3]

The history of the Zhili/Hebei area of North China poses questions of enormous consequence. How could this area maintain its political centrality for so many centuries despite a relatively weak economic base? How could substantial population growth be sustained in the face of what appear in the historical record to be frequent and regular occurrences of drought and flood?

THE PRICE DATA

During the Qing dynasty each provincial governor was required to submit to the throne a monthly report of grain prices in his province. This became a regular bureaucratic practice by the beginning of the Qianlong period in 1736. The Qing archives in Beijing and Taibei have a rather complete set of reports from Zhili for the eighteenth century and a more scattered sampling from the nineteenth century. I have collected approximately 609 of these monthly lists, including 233 monthly lists for 1738–64, 171 lists for 1765–95, and 205 lists for 1796–1910.[4]

In the first subperiod, 1738–64, the lists give the low and high prices of seven types of grain from each prefecture (*fu*) or independent department (*zhilizhou*) in the province: rice (*daomi*), high-grade millet (*shang sumi*), ordinary millet (*cisumi* or *zhongsumi*), white wheat (*baimai*), red wheat (*hongmai*), black beans (*heidou*), and sorghum, or kaoliang (*gaoliang*). After 1765 only five grains were reported: millet (*sumi*), sorghum (*gaoliang*), a type of panicum millet (*nimi*), wheat (*mai*), and black beans (*heidou*).[5]

Prices from seventeen prefectures or independent departments were reported by the governor-general of Zhili, although not all were reported in every period. Shuntian Prefecture (where Beijing was located) was not included until 1771. Chengde Prefecture was not included in the reports until

3. The Qing figures are taken from Philip C. C. Huang, *The Peasant Economy and Social Change in North China* (Stanford, 1985), p. 322. The 1982 figure is reported in Judith Banister, *China's Changing Population* (Stanford, 1987), pp. 298–99, among other places.

4. I am indebted to the staff of the Ming-Qing archives of the National Palace Museum in Taibei and the First Historical Archives in Beijing for allowing me access to these grain price lists.

5. *Sumi* was *Setaria italica*, sometimes called foxtail millet, which was the most common type of millet grown in north China. *Nimi* was *Panicum milaceum*, sometimes called broomcorn millet. *Heidou*, lit. "black bean," was a type of soybean. See Francesca Bray, *Agriculture*, vol. 6, pt. 2 of Joseph Needham et al., *Science and Civilization in China* (Cambridge, Eng., 1984), pp. 434–48.

1778. From 1736–68, the prices for Baoding Prefecture, the location of the provincial capital, were reported a month in advance of the other provinces.

These grain price reports were submitted monthly, according to the Chinese lunar calendar—with intercalary months ("leap months") added from time to time to make the lunar year catch up to the solar year. Since any given lunar month might lag behind its corresponding solar month by up to two months, solar months might be more appropriate to use in studying the agricultural cycle. In this study lunar-month prices have been used where aggregated data for year or multiyear periods would cancel out the variations in the months. However, where seasonality is an important concern, data are converted to correspond with the solar months.

AGRICULTURE AND FOOD AVAILABILITY IN ZHILI

As the above lists suggest, many grain crops were grown in Zhili. Although rice was the subject of experimentation in the early eighteenth century, it was never very widely grown.[6] Wheat was the luxury grain in the North. Planted in the fall, it was harvested the following summer. Millets of various types were the staple of the poor people's diet. Like sorghum, millet was planted in late spring and harvested in the fall. It was hardy, having a tolerance for heat and drought. Sorghum, on the other hand, was more flood-resistant. Less desirable than millet as a food, sorghum was also used in making wine, and its stalks were burned for fuel.

Other crops were important too. Black beans, reported in the Qing grain price reports, were used both as a feedgrain for horses and as food for humans. They also became a cash crop, used in the production of oil. In the twentieth century corn became a major food crop, but it is not at all clear how extensively it was grown in the Qing period. Finally, cotton was the most important nonfood commercial crop in Zhili in Qing and later times, but the extent of its cultivation before the twentieth century is a matter of some uncertainty.[7]

There were numerous cropping systems in North China, with great variation within regions. One system was a three crop rotation over two years. As Philip C. C. Huang describes it, sorghum and millet were planted in May or June and harvested in September or October. Wheat was planted in the fall and harvested in July, too late for the planting of sorghum or millet, so soy-

6. See Timothy Brook, "The Spread of Rice Cultivation and Rice Technology into the Hebei Region in the Ming and Qing," in *Explorations in the History of Science and Technology in China* (Shanghai, 1982), pp. 659–89, for an exhaustive study of experimentation in rice cultivation in North China.

7. Philip C. C. Huang, pp. 111–14, asserts that cotton cultivation was widespread in Zhili by the late Ming period, but others have disputed this. See, for example, Loren Brandt's review of Huang, *Peasant Economy*, in *Economic Development and Cultural Change* 35 (April 1987):670–82.

beans were planted for harvesting in October and November, after which the land would be left fallow. Other systems involved interplanting.[8]

It is not until the twentieth century that we have some idea of the acreage devoted to each of these major crops. John Lossing Buck's well-known 1929–33 farm study reports that in the winter wheat–kaoliang region, which included Hebei, wheat accounted for 45.5 percent of crop area, millet for 23.1 percent, sorghum for 18.5, corn for 16.3, soybeans for 13.4, and cotton for 8.6.[9] A survey conducted by Zhang Xinyi reports the following crop areas for Hebei in the 1930s: wheat, 31.3 million *mu* (28 percent), millet, 24.3 million *mu* (22 percent), sorghum, 21.7 million *mu* (20 percent), and corn, 15.5 million *mu* (14 percent). Beans (*dadou*) accounted for 9.8 million *mu* (9 percent), and cotton for 8.1 million *mu* (7 percent).[10]

These two estimates are similar in that they show the primary importance of wheat, millet, and sorghum, in that order. There is, of course, every reason to believe that the situation in the Qing period differed in significant ways. Corn almost certainly played a lesser role, and perhaps the proportions of wheat, millet, and sorghum were different from the twentieth century. Unless further research uncovers new sources, it is unlikely that we shall ever have an exact picture of the production of these crops during the Qing period, but this general picture of the relative importance of these crops is unlikely to be changed.

This study analyzes the prices of three of the grains reported in the Qing memorials—wheat, millet (*sumi* or setaria millet), and sorghum—because of their centrality in the agriculture and the diet of the North. Black beans probably did not constitute a significant portion of the caloric content of the average diet. Panicum millet and rice were unlikely to have been of critical importance either.

Two additional factors probably influenced the price structure, although they were exogenous to Zhili's agricultural production. First, a significant portion of the grain consumed in Zhili during the Qing was not grown in the province but was imported from the South through the grain tribute system. During the Qing, 3–4 million *shi* of grain were transported annually to the metropolitan area.[11] Most of this was destined for the consumption of the court, bannermen, and soldiers stationed in the province. But it is quite likely

8. Philip C. C. Huang, *Peasant Economy*, p. 61.

9. John Lossing Buck, *Land Utilization in China* (Chicago and Nanking, 1937; repr. New York, 1956), 1:211–12. Because there was some double cropping, the percentages exceed 100.

10. Cited in *Shina nōgyo kiso tōkei shiryo*, comp. Tōa kenkyūjo (Shanghai, 1941), 1:41–43.

11. The *shi* was a measure of grain volume. According to an authoritative estimate, "the likely weight of an imperial shih [*shi*] of milled rice in the eighteenth century was about 185 pounds, with a margin of error unlikely to have been more than 5 percent either way (that is, the likely range was roughly 175 to 195 pounds)." Han-sheng Chuan and Richard A. Kraus, *Mid-Ch'ing Rice Markets and Trade: An Essay in Price History* (Cambridge, Mass., 1975), p. 98.

that some quantity of grain reached the market, through either direct or indirect sales. Pierre-Etienne Will has estimated that 0.5 million *shi* a year was not used for direct consumption in Beijing.[12] Whether this amount was sufficient to have an impact on general grain price levels is not clear, and is a matter that deserves further investigation.

The second factor was an extensive state granary system, which flourished in the eighteenth century. The system included three types of granaries: the "ever-normal" granaries, the community granaries, and the charity granaries. During the eighteenth century these granaries were well stocked. In 1767, for example, the governor-general of the province reported that 3,534,536 *shi* of grain were actually stored in the province, 2,549,566 *shi* of which were in the ever-normal granaries.[13] By the nineteenth century, however, all granary holdings were down, especially those of the ever-normal granaries. In 1833, for example, the governor-general reported holdings of only about 616,000 *shi*, of which 275,719 *shi* were held in ever-normal granaries.[14]

LONG-TERM TRENDS

The Zhili price series affords an important opportunity to learn about the long-term behavior of prices over two centuries. This is important not only because of its relevance to a study of Zhili's economy in particular but also because it can serve as a general indicator of overall economic trends in North China. The price trend of these three major grains has several major characteristics. As Figure 2.1 shows, the overall price rise from 1738 to 1910 was not steep. During the eighteenth century prices rose very gradually. In the early part of the nineteenth century, there was a sharp increase in the price of wheat, followed by rises in the prices of millet and sorghum. From the 1830s to 1850, roughly during the Daoguang reign, prices fell precipitously, only to climb back up by 1870 and fall again. From 1890, prices rose steeply and steadily until the end of the dynasty. When these same prices, again grouped by four-year averages, are indexed to their base-period (1738–41) prices, the trends can be seen more clearly, as in Figure 2.2. At the end of the eighteenth century, the prices of wheat, millet, and sorghum were respectively only 134 percent, 122 percent, and 133 percent of the base-period prices. By the end of the dynasty, the three grains had risen to 258 percent, 243 percent, and 272

12. Pierre-Etienne Will, *Bureaucratie et famine en Chine au 18e siècle* (Paris, 1980), pp. 241–44. Will points out that tribute grain surpluses were rarely used outside Zhili.

13. Gongzhongdang, Palace Memorial Archives (Taibei), Qianlong 023616, 1767/12/12. These figures represent the actual holdings at the time of the report; the theoretical holdings, which took into account amounts loaned out but not yet paid back to the granaries, were larger.

14. Junjidang, Grand Council Archives (Beijing), Daoguang 63339, 1833/4. These figures represent actual, not theoretical, holdings.

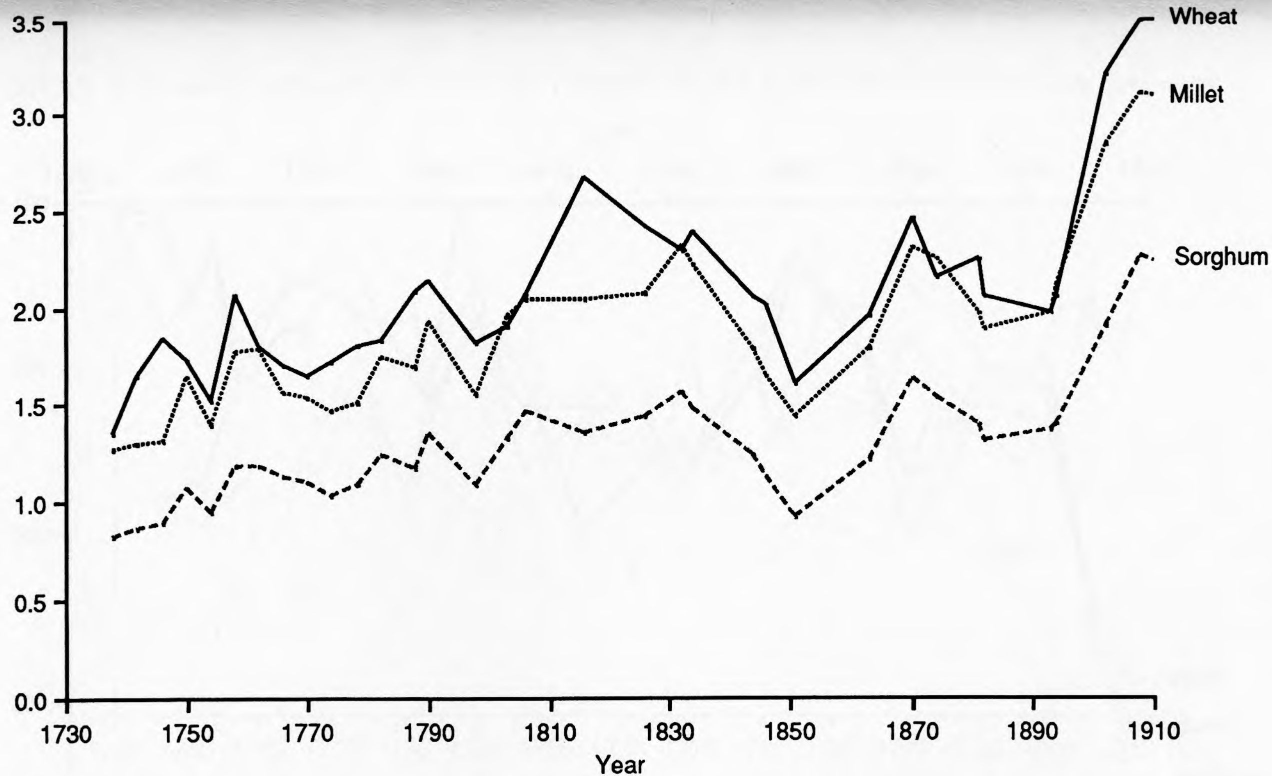


Fig. 2.1. Grain Prices in Zhili Province, 1738–1910 (four-year averages, in taels per *shi*)
Note: See text for a description of the data used in this study. In Figs. 2.1, 2.2, and 2.4, there is a substantial amount of missing data for the nineteenth century.

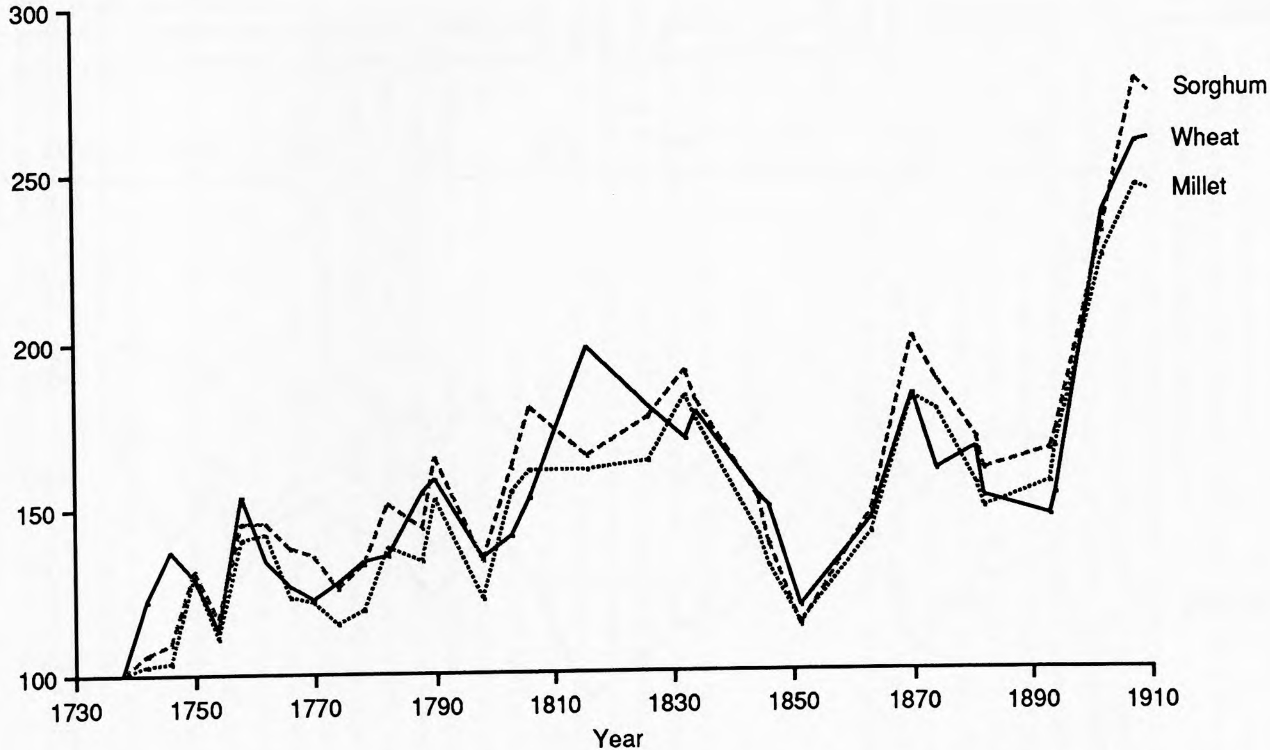


Fig. 2.2. Grain Prices in Zhili Province, 1738–1910: Indexed to the Base Period (four year averages; 1738–1741 = 100)

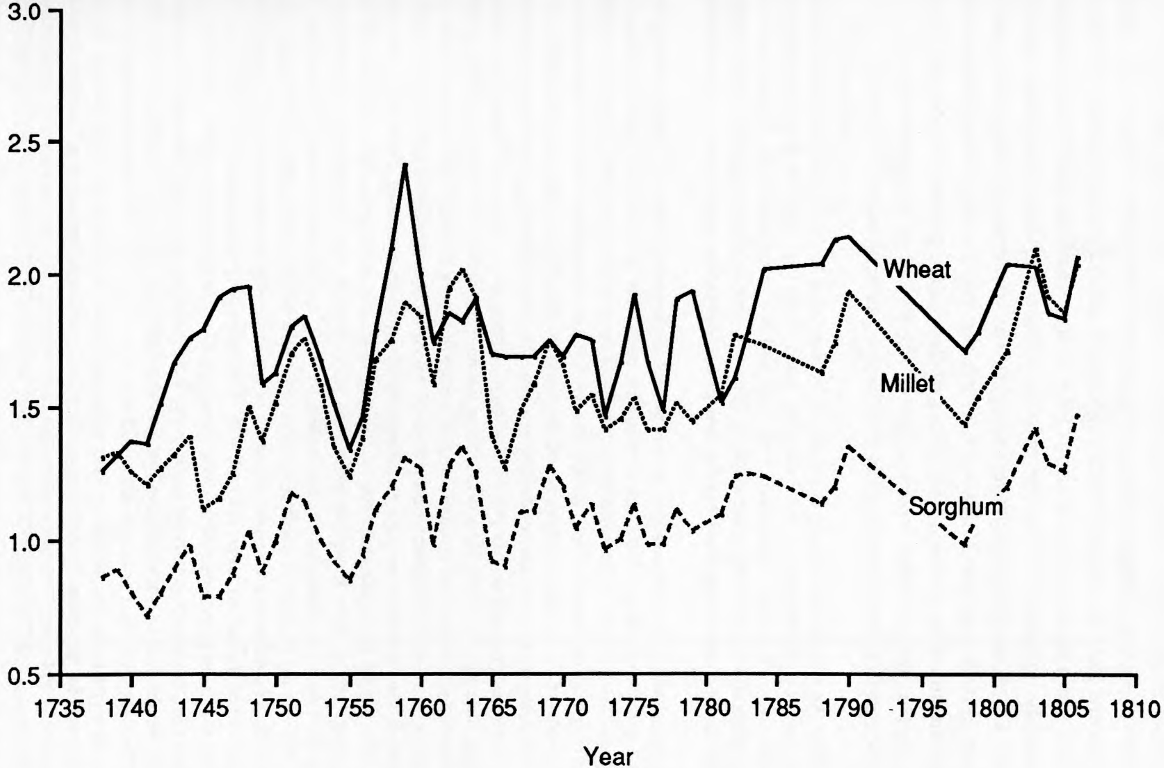


Fig. 2.3. Annual Grain Prices in Zhili Province, 1738–1806 (taels per *shi*)

percent of the base-period prices respectively, but if the final two decades of the dynasty are omitted, the increases are only 146 percent, 155 percent, and 165 percent respectively of the base-period price.

To show more clearly what the annual trends looked like, in Figure 2.3 I present the annual averages (unadjusted) for 1738–1806.[15] Here once again it is apparent that the trend for the eighteenth century was not very steep and that there seem to be cycles of about four to five years for millet and sorghum and possibly longer cycles in the price of wheat. Further, it appears that the prices of all three grains followed roughly the same trend, but there was at least one period—in the 1740s—in which the rise in the price of wheat was not accompanied by a rise in the prices of the coarse grains. A contrary trend is seen in the early 1760s, when a rise in the prices of the coarse grains was not accompanied by a continuous rise in the price of wheat.

15. Only the eighteenth century is presented because that is the century for which the data are most complete. In this essay I have used the mean of the high and low prices reported from each prefecture each month. In analyzing the high and low prices separately, I found that their behavior generally followed the same pattern. This was true of all three grains. There seemed, then, little point in studying either high or low prices separately, particularly in a preliminary study.

The adjustment of annual averages to account for the seasonal variations in the missing data presents a greater challenge. Although it would be preferable to adjust the annual averages, in fact each possible procedure for adjustment produces its own problems. One way is to estimate, or "predict," missing data by using all the known data in combination with the seasonal coefficients produced by the regression equation discussed in the next section. Another method is to adjust each known piece of data by its relevant monthly coefficient. This creates not an annual average but an estimated January price based on all known data. Until a more accurate method of adjusting data can be found, however, leaving the data unadjusted does not, I believe, produce large distortions, because the annual seasonal range of prices in Zhili was not more than 0.14 tael in the extreme case of wheat (from a high of +0.08 taels in April to a low of −0.06 taels in September in the regression on data excluding Baoding, as presented in Table 2.1). For example, in 1740, a year for which there are no missing data, the mean price was 1.38 taels. If data were missing for the three low-price months of July, August, and September, the unadjusted mean of the other nine months of data would be 1.40, a distortion of only 0.02 tael, or 1.4 percent. If I use the regression coefficients to estimate the missing data, the annual mean would come to 1.39. The difference between adjusting or not adjusting the data is only 0.01 tael, or less than 1 percent of the actual mean price of 1.38. This example presents one of the worst possible cases since the mean price was rather low in comparison to the rest of the period 1738–1910. In a year when the prices were relatively high—over 2.50 taels, for example—the use of a seasonal coefficient would tend to underestimate the missing data (e.g., 0.06 tael would make less difference). The only time that a larger distortion might be introduced by not adjusting the data would be in a crisis year for which we have only one month of data in the early part of the year not yet affected by the crisis. In such a case, the price level would be very much underestimated. If, instead of "predicting" the price where data are missing, we use the seasonal coefficients to adjust the known data, the result in this example would be 1.37, only 0.01 less than the actual mean price. The fact that this hypothetical January price is close to the mean is somewhat accidental; the actual January price for that year was 1.42, which reflects the fact that the previous year was a crisis year (see n. 21 below) and that the price of wheat was abnormally high in the winter months.

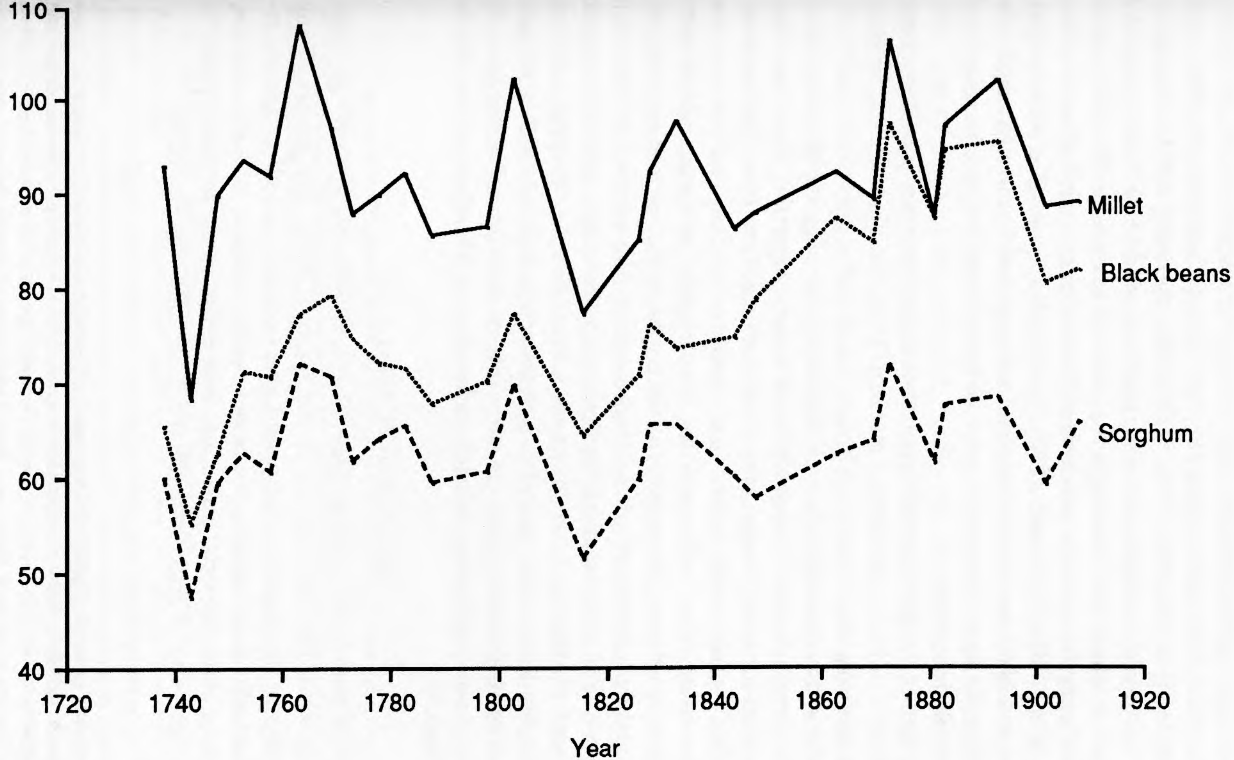


Fig. 2.4. Prices of Coarse Grains Relative to Wheat in Zhili Province, 1738–1910 (5-year averages; price = % of wheat price in concurrent period)

On the whole these graphs show that the prices of millet and sorghum followed each other very closely, with sorghum consistently being the cheaper of the two. Although millet was a less desirable grain than wheat, the figures show that there were years when its price approached that of wheat (and even exceeded it in the early 1760s, early 1780s, and early 1800s). Figure 2.4 charts the five-year averages of millet, sorghum, and black bean prices as a percentage of wheat price averages for the concurrent periods. This shows more clearly the few periods in which millet prices exceeded those of wheat (around 1760, 1800, 1870, and 1890). And it also shows that while millet, sorghum, and black bean prices maintained a spread in the eighteenth century, during the next century the price of black beans relative to wheat and millet steadily increased.

These trends suggest certain hypotheses about the roles played by these commodities in Zhili's agricultural markets. First, the generally higher price of wheat confirms that it was the luxury grain and suggests the possibility that its markets were relatively well developed. Second, the price trends of millet and sorghum seem to parallel each other, suggesting that they were responding to the same cropping cycle and weather patterns. On the other hand, millet's consistently higher price confirms our impressions from the twentieth century that millet was the staple grain and was valued more highly than sorghum. However, the fact that millet prices occasionally reached, and even surpassed, those of wheat raises the question of the extent to which it was a commercialized agricultural commodity and the extent to which it was considered a substitute for wheat. Finally, the price of black beans rose relative to wheat prices in a clear secular trend, probably because of a growing nationwide, perhaps even international, market for bean oil and other bean products produced primarily in Manchuria but also in North China.[16]

REGRESSION ANALYSIS

At any given month, the price of grain may have reflected not only the long-term price trend but also a place in the seasonal cycle, the impact of any irregularities in the weather that would affect output, as well as any exogenous factors affecting demand. To permit us to estimate, and separate out, the effects of time, seasonal variation, and crisis years on grain prices, a multiple regression of prices was run using the following equation:

$$P = a + bT + d_2M_2 + d_3M_3 + \ldots + d_{12}M_{12} + dC$$

16. The extent to which Zhili/Hebei was involved in this industry is a subject that awaits further research. Certainly in the twentieth century one of Manchuria's principal industries and export commodities was soybean oil and other soybean products. See, for example, Lien-en Tsao, "The Marketing of Soya Beans and Bean Oil," *Chinese Economic Journal* 7, no. 3 (Sept. 1930): 941–71.

Here the price in any given month (P) is measured by a constant (a), plus a coefficient (b) multiplied by time (T), plus dummy variables (d) that are created for every month (M) except January and another dummy variable created for crisis years (C). The dummy variable C is entered as a 1 in a crisis year and as a 0 in noncrisis years.[17]

Since one of the purposes of this regression is to measure the effect of seasonality, all data used in the analysis were converted to solar prices using a method that weights the price by the number of appropriate lunar days in each solar month.[18] Since prices for Baoding, the seat of the provincial capital, were routinely reported a month in advance of prices from other prefectures during 1736–68, a period that represents 44 percent of my data (268 out of 609 monthly reports), I also ran the regression with Baoding prices excluded lest the months for which there are only Baoding prices unduly affect the results.[19]

The most problematic decision in setting up this regression concerned the crisis years. Although it would be ideal to use meteorological data (temperature and rainfall) to code years of crisis, I do not yet have access to such data. In their absence, I am forced to rely on reports of crises found in the historical records. Since such data represent the human (social and political) impact of natural disasters as seen through administrative lenses, they must necessarily have their limitations. The historical record itself is necessarily subjective, and our access to it is also incomplete, a function of what documents have survived in which collections and archives. In this regression analysis I selected as crisis years those years recorded in *Qingdai Haihe Luanhe honglao dang'an shiliao*[20] as having floods that affected 50 counties (*xian*) or more. Although this compilation itself may be flawed, it is drawn from a survey of local gazetteers. In addition I selected from miscellaneous records at my

17. This regression equation was also run with T^2 as a variable to see if there were perhaps a nonlinear relationship between time and price. The results were not statistically significant ($t < 2$), and overall did not produce a better R^2, and so we concluded that there is not a second-order relationship between time and price.

18. I am very grateful to Peter C. Perdue for providing the complex formula and table by which the lunar data have been converted to solar data and to Keith Head, who wrote the program that adapted this table to my data.

19. For example, the price list submitted by the Zhili governor-general reporting prices for the third lunar month included the fourth-month prices for Baoding Prefecture, presumably because these local prices were already available to him by the time he received the third-month prices from the outlying prefectures. Consequently, if I have the third-month provincial report but am missing the fourth-month provincial report, the Baoding price is the only one I have for the fourth month and the provincial average in fact represents only Baoding. Because there is reason to think that prices behaved differently in the capital, I have thought it wise to run the regression both with and without Baoding prices.

20. *Qingdai Haihe Luanhe honglao dang'an shiliao* (Beijing, 1981).

TABLE 2.1 Annual Trends and Seasonal Variation in Grain Prices in Zhili Province, 1738–1910
(regression coefficients, in taels per *shi)*

	Wheat Price		*Millet Price*		*Sorghum Price*	
Variable	Excluding Baoding	Including Baoding	Excluding Baoding	Including Baoding	Excluding Baoding	Including Baoding
Crisis year	0.06	0.08	0.06	0.07	0.01	0.02
Time (1738 = 0)	0.0059	0.0056	0.0061	0.0061	0.0045	0.0045
February	0.01	0.01	0.03	0.03	0.02	0.02
March	0.04	0.03	0.05	0.04	0.05	0.04
April	0.08	0.05	0.06	0.05	0.06	0.05
May	0.06	0.05	0.06	0.06	0.06	0.06
June	0.02	0.01	0.07	0.07	0.08	0.08
July	- 0.05	- 0.04	0.09	0.09	0.08	0.09
August	- 0.04	- 0.06	0.09	0.11	0.08	0.08
September	- 0.06	- 0.08	0.06	0.05	0.02	0.01
October	0.02	- 0.01	0.08	0.05	0.04	0.02
November	0.02	- 0.02	0.03	0.01	0.01	- 0.01
December	0.02	- 0.02	0.00	0.02	0.01	0.01
Constant	1.56	1.62	1.30	1.33	.87	.90
R^2	.49	.44	.59	.56	.58	.55
F	40.13	37.99	61.07	61.59	57.79	58.12

disposal years in which 25 or more counties were affected by drought. This combined method yielded 54 years that were coded as crisis years.[21]

When the regression was run for 1738–1910, with Baoding prices excluded, the results (see Table 2.1) showed that the effect of time was 0.0059, 0.0061, and 0.0045 taels for wheat, millet, and sorghum respectively, meaning that for each year, the price increased by this amount for each grain. These increases confirm the impression, derived from Figure 2.1, that the inflationary trend was not very steep or significant over this long time period.

The regression results show the monthly variation of prices, using January as the base month. The results, graphed in Figure 2.5, show the effect of the multiple-crop system of Zhili. Wheat prices reached their peak in April but did not reach their lowest point until September—somewhat surprisingly, since the wheat harvest took place around July. Millet and sorghum prices, however, peaked in June, July, and August, from which point they fell until

21. 1738, 1739, 1743, 1744, 1747, 1750, 1759, 1761, 1762, 1771, 1780, 1790, 1794, 1801, 1806, 1808, 1810, 1813, 1814, 1816, 1819, 1820, 1822, 1823, 1830, 1832, 1834, 1835, 1839, 1840, 1855, 1871–73, 1876, 1877, 1879, 1882, 1883, 1886–90, 1892–1900, and 1908. Of course, I lack price data for many of these years.

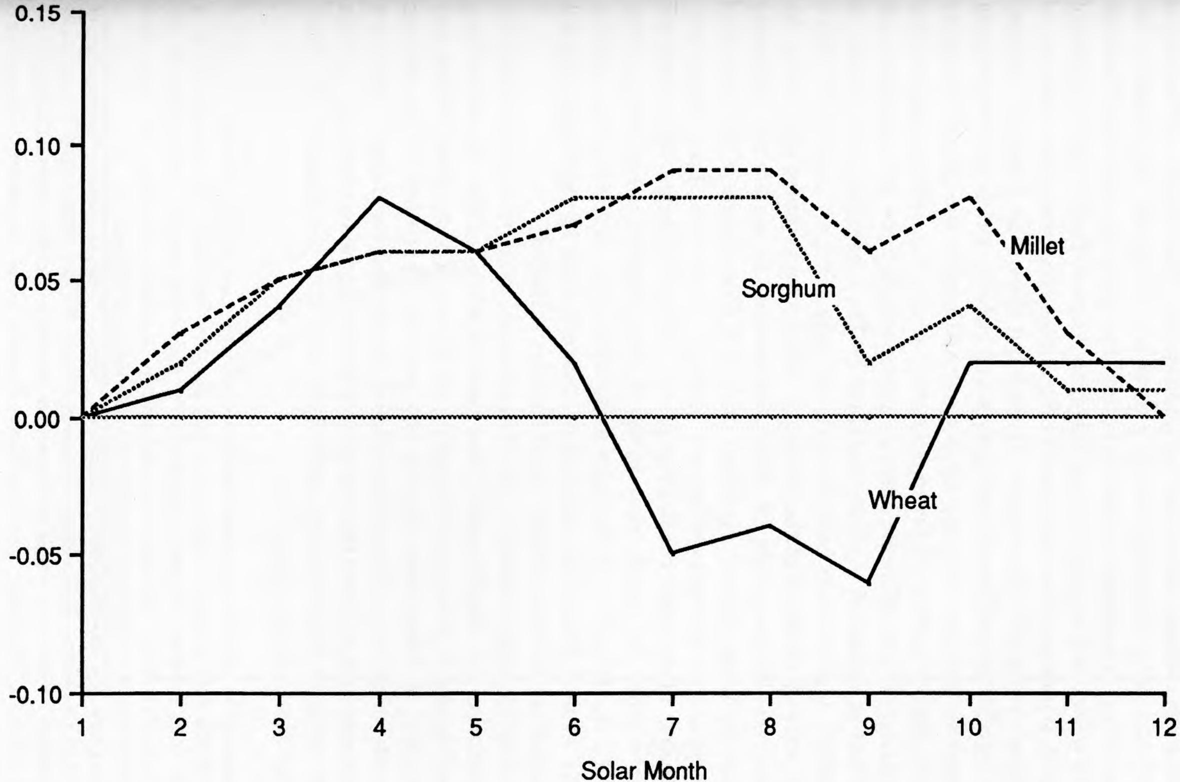


Fig. 2.5. Seasonal Variation of Grain Prices in Zhili Province (Excluding Baoding), 1738–1910 (difference from January price, in taels per *shi*)

the end of the year, with a brief jump in October. The prices of all three grains rose steadily through the early months of the year. But if Baoding is included, as in Figure 2.6, there is a smoother descent for wheat in the fall, but in October, wheat, millet, and sorghum prices peak briefly. If Baoding is included and only eighteenth-century data are analyzed, the shape of the seasonal curves is smoother, with the annual low price for wheat and the high prices for millet and sorghum all occurring in August. Preliminary analysis of price data separately for each prefecture shows that the exact patterns of seasonality vary slightly from place to place but fall within a general pattern.

The regression coefficients also vary when either eighteenth-century data or nineteenth-century data are used alone. Although the greater quantity and likely higher quality of the eighteenth-century data would suggest that its regression results would be more significant, in fact the R^2—a measure of the amount of variation in price explained by the regression as a whole—is considerably higher when both centuries of data are used together.[22] When a Chow test—a measure of the extent to which two samples may affect the regression results—was run on these regressions, no significant difference was found between the two centuries of data.[23] Consequently, the results of the regression run on both centuries of data are used throughout this paper.

These sets of monthly coefficients present several puzzles. Why does the annual low price for wheat come so much later than its presumed harvest-time? Why do the prices of sorghum and millet jump around in the autumn and early winter? Why does the seasonal pattern seem to vary depending on the time period and the number of prefectures included?

One possible explanation may be that seasonal patterns do differ from one area to another. In Buck's survey, the price of wheat in the wheat-kaoliang area was highest in January–February, and lowest in May–June. Millet had its high price in May–June and its low price in November.[24] But another 1930s study of prices in Zhengding, Hebei, found that the annual high price for wheat was in April, and the low price followed immediately in May, while the high price of millet was in June–July, and the low immediately afterward, in August–September.[25]

22. Running the regression on either eighteenth- or nineteenth-century data alone produced much lower R^2s than using two centuries of data together. For wheat, for example, the R^2 is 0.4859 for both centuries together, 0.2029 for the eighteenth century, and 0.1662 for the nineteenth century. These differences are undoubtedly due to the strength of the time trend, which is by far the most significant variable in any of these regressions.

23. The Chow test was developed by Gregory C. Chow, "Tests of Equality between Sets of Coefficients in Two Linear Regressions," *Econometrica* 28, no. 3 (July 1960):591–605. I am grateful to F. Michael Scherer, formerly of the Economics Department at Swarthmore College, for his help with this test. The F-ratio was insignificant for both wheat and millet (0.83 and 0.63, respectively) and marginally significant for sorghum (1.80).

24. Buck, *Land Utilization in China*, 1:335–36.

25. "The Seasonal Variation of Prices for Farm Products and the Profitability of Storage," *Economic Facts*, no. 7 (October 1937):319–42.

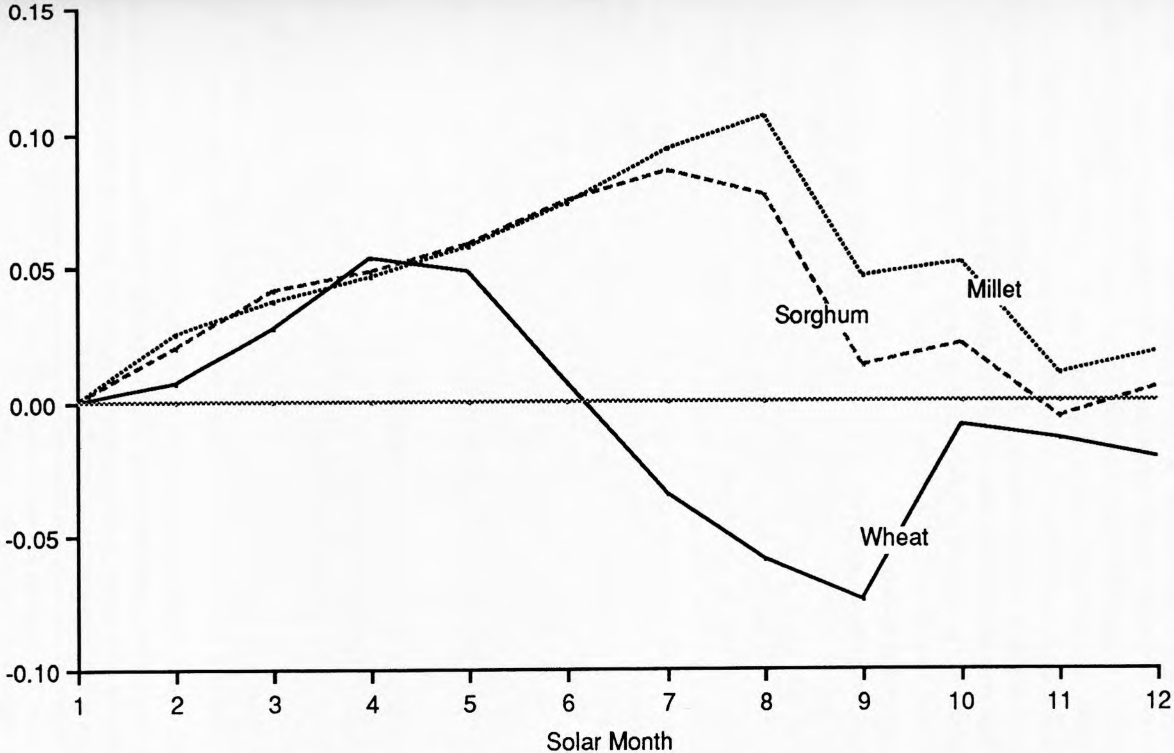


Fig. 2.6. Seasonal Variation of Grain Prices in Zhili Province (Including Baoding), 1738–1910 (difference from January price, in taels per *shi*)

The irregularities in the autumn prices could also be explained by deliveries of grain tribute to the province, which occurred before winter, or alternatively by the restocking of granaries, which was also done in the autumn. Since it was mostly unhusked millet that was stored (because wheat spoils too quickly), post-harvest prices may have risen a bit before falling to their annual low at the end of the year.[26]

Although the precise effects of seasonality seem to differ according to the way the regression is run, the overall pattern is clear. Moreover, the regression analysis reveals that the effect of seasonality was less important than the effect of crises.[27] The spread of prices within each year was less than 0.14 tael for wheat and less than 0.11 tael for millet and sorghum, no matter which way the regression is run.

Although regression analysis is a sophisticated tool for measuring the separate effects of different variables on price, it has its limitations. For the purposes of this grain price analysis, it can give us a good measure of the factors in price variability, but it is sensitive to differences in time and space and therefore cannot be absolutely accurate. It must be used as an approximate tool, not a precise measure. In future work, more accurate specification of crisis years, more complete data, and work with disaggregated, prefectural data may produce more satisfactory results. Still, these preliminary results do inspire some confidence. Although the t-value for each of the monthly coefficients tends to be under 2, in using descriptive data, as opposed to sampling, t-values are not relevant. Moreover, the R^2s achieved here are not poor, and the F-values are so large that the overall strength of the regression variables can be seen to be very substantial.[28]

CRISES

One purpose of the regression analysis is to try to measure the effect of crises on price levels. The regression analysis for 1738–1910 suggests that the effect of a crisis year was, on the whole, not very dramatic. The inclusion of Baoding data raises the effect slightly (see Table 2.1). A separate regression run solely on Baoding data results in higher crisis coefficients. Moreover, if the

26. Pierre-Etienne Will and R. Bin Wong, *Nourish the People: The State Civilian Granary System in China, 1650–1850* (Ann Arbor, 1991), manuscript pp. 5, 132. Thirty percent of the granary stock was supposed to be sold off each year and replaced.

27. This impression was confirmed when the regression was run with only the monthly dummies as variables. The resulting R^2s were astonishingly low: 0.0099, 0.0129, and 0.0189 for the three grains, respectively. Running the regression with interaction variables ($C{*}M$, $C{*}T$, etc.) also produced very low R^2s showing that a nonlinear relationship was not a better explanation for the behavior of prices.

28. Concerning these and other statistical problems, I am grateful to Gudmund Iversen, professor of statistics at Swarthmore College, for his judgment and invaluable suggestions.

TABLE 2.2 Grain Price Increases in Crisis Years in Zhili Province, 1738–1910 (regression coefficients, in taels per *shi*)

Period	*Wheat Price*	*Millet Price*	*Sorghum Price*
Year, including Baoding	0.08	0.07	0.02
Year, excluding Baoding	0.06	0.06	0.01
Year, Baoding only	0.14	0.08	0.03
Crop year, including Baoding	0.09	0.15	0.11
Crop year, excluding Baoding	0.04	0.13	0.08
Crop year, Baoding only	0.12	0.14	0.13

monthly price data are divided into a "crop year," from July to the end of June, the effect of crises is seen to be far higher for the coarse grains but slightly lower for wheat. Table 2.2 summarizes the coefficients generated in these various ways. In all cases the R^2s are very similar, as are the coefficients for time. The monthly coefficients vary, but are within two standard errors of zero.

Dividing the year at July generates a higher coefficient for the crisis variable, because a crop year more closely approximates the seasonal weather pattern in the North. Since July and August are the months of greatest annual rainfall, droughts and floods have their first impact in the second half of the year and the next winter. They affect the coarse grains first. Although sorghum is known to be flood-resistant, its price seems to be the most differentially affected by the use of this technique. Overall, however, the price of millet was the most affected in a year of crisis.

The fact that Baoding prices were more affected by crises than prices in the rest of the province raises some interesting questions. As the seat of the provincial capital, Baoding Prefecture might be expected to have higher prices than outlying prefectures because of a stronger demand for grains. Its wheat prices were much more affected by crises than wheat prices in the rest of the province, suggesting a stronger demand for the luxury grain in the capital than elsewhere.

Tables 2.3, 2.4, and 2.5 attempt to evaluate the effect of natural disasters on grain prices in three crisis periods.[29] The tables compare the actual prices of the three grains with their predicted prices (for a noncrisis year), calculated with the regression coefficients presented in Table 2.1, using data for 1738–1910 but excluding Baoding.

29. The period 1743–44 was chosen because it is a well-studied drought, the periods 1762–63 and 1775–76 because the data were relatively complete. Although 1775–76 is identified in documentary sources as a drought period, these years are not coded as crisis years in the regression analysis (see n. 21 above) because fewer than 25 counties were apparently affected.

$$\text{Predicted Price} = a + b(\text{Time}) + \text{Monthly effects}$$

Time is the year minus 1738. Each case study covers the two calendar years that include the period of crisis.

In 1743–44 Zhili experienced a drought. As Table 2.3 shows, the actual prices of all three grains at the beginning of 1743 were below the predicted prices, particularly so for millet and sorghum. However, by May and June, when wheat prices should have fallen, they instead continued to rise, reflecting a poor harvest or an impending harvest. Although the data for the key months of the crisis, from summer 1743 to summer 1744, are missing, we can see that by July 1744 the prices of wheat and millet had risen 0.20 tael above the predicted price, and the price of sorghum, 0.15 tael. By the end of the calendar year, however, the price of wheat was almost down to the predicted level, and the prices of millet and sorghum had fallen to well below the predicted prices.

Although the actual prices at their peak reflected the impact of the drought more than the crisis coefficients of 0.06, 0.06, and 0.01 predicted they would, nevertheless it can certainly be concluded that the overall impact of the drought was rather limited in magnitude and duration. This substantiates to a considerable degree the picture of this crisis drawn by Pierre-Etienne Will.[30] First, the impact of the drought, according to the historical record, was limited to 27 counties, primarily in four prefectures. Second, these counties were the recipients of massive amounts of government relief, deployed from several sources, most notably the state granaries in Tongzhou. The grain prices in these prefectures taken separately show no difference from the provincial trends. The famine relief campaign mounted by the government was truly a model effort, and the price history seems to show that the efforts of the Qing officials were well rewarded.

Table 2.4 presents the predicted and actual prices during and after a flood in 1775, which had been preceded by a drought in 1774, to show what the conditions were in a crisis where the government may have played a less active role. In this case, it appears that wheat prices were the most seriously affected. By September 1775 wheat prices were 0.20 tael above the predicted price, and prices stayed high until June, when an apparently successful harvest sent prices tumbling down to well under their predicted or normal levels. Millet prices were close to their normal levels in the spring and summer of 1775, while sorghum prices rose 0.10 tael or slightly more. But after the fall 1775 harvest, which does not seem to have been much affected by the flood, both millet and sorghum prices fell and stayed below their predicted levels in 1776. So the main impact of the crisis fell on wheat, and as in 1743–44, the impact was limited in magnitude and duration.

30. See Will, *Bureaucratie et Famine.*

TABLE 2.3 Grain Prices during the 1743–1744 Drought in Zhili Province (Excluding Baoding) (in taels per *shi*)

	Wheat Price			*Millet Price*			*Sorghum Price*		
Year and Month[a]	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]
1743									
January	1.59	1.55	- .04	1.33	1.19	- .14	0.90	0.76	- .14
February	1.60	1.56	- .04	1.36	1.20	- .16	0.92	0.78	- .14
March	1.62	1.57	- .05	1.38	1.22	- .16	0.94	0.82	- .12
April	1.66	1.61	- .05	1.39	1.25	- .14	0.95	0.84	- .11
May	1.65	1.65	.00	1.39	1.28	- .11	0.96	0.86	- .10
June	1.61	1.68	+ .07	1.40	1.31	- .09	0.97	0.88	- .09
July	1.54	—	—	1.42	—	—	0.98	—	—
August	1.55	—	—	1.42	—	—	0.98	—	—
September	1.53	—	—	1.39	—	—	0.92	—	—
October	1.61	—	—	1.41	—	—	0.94	—	—
November	1.60	—	—	1.36	—	—	0.91	—	—
December	1.61	—	—	1.34	—	—	0.91	—	—
1744									
January	1.59	—	—	1.34	—	—	0.90	—	—
February	1.61	—	—	1.37	—	—	0.92	—	—
March	1.63	—	—	1.39	—	—	0.95	—	—
April	1.67	—	—	1.40	—	—	0.96	—	—
May	1.65	—	—	1.40	—	—	0.96	—	—
June	1.61	—	—	1.41	—	—	0.98	—	—
July	1.54	1.74	+ .20	1.43	1.62	+ .19	0.99	1.14	+ .15
August	1.55	—	—	1.43	—	—	0.98	—	—
September	1.53	1.71	+ .18	1.40	1.32	- .08	0.92	0.91	- .01
October	1.62	—	—	1.42	—	—	0.94	—	—
November	1.61	1.68	+ .07	1.37	1.09	- .28	0.91	0.77	- .14
December	1.62	1.65	+ .03	1.34	1.09	- .25	0.91	0.77	- .14

[a] Months are solar. [b] Actual minus predicted price.

TABLE 2.4 Grain Prices during the 1775–1776 Drought and Flood in Zhili Province (Excluding Baoding) (in taels per *shi*)

Year and Month[a]	*Wheat Price*			*Millet Price*			*Sorghum Price*		
	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]
1775									
January	1.77	1.80	+ .03	1.53	1.51	– .02	1.04	1.08	+ .04
February	1.79	1.80	+ .01	1.56	1.51	– .05	1.06	1.08	+ .02
March	1.81	1.87	+ .06	1.58	1.55	– .03	1.09	1.13	+ .04
April	1.85	1.91	+ .06	1.59	1.60	+ .01	1.10	1.18	+ .08
May	1.84	1.94	+ .10	1.59	1.62	+ .03	1.11	1.21	+ .10
June	1.80	1.92	+ .12	1.60	1.60	.00	1.12	1.21	+ .09
July	1.72	1.88	+ .16	1.62	1.61	– .01	1.13	1.23	+ .10
August	1.73	1.89	+ .16	1.62	1.60	– .02	1.12	1.24	+ .12
September	1.72	1.92	+ .20	1.59	1.58	– .01	1.06	1.20	+ .14
October	1.80	1.93	+ .13	1.60	1.46	– .14	1.08	1.08	.00
November	1.79	1.96	+ .17	1.56	1.40	– .16	1.05	1.02	– .03
December	1.80	1.96	+ .16	1.53	1.39	– .14	1.05	0.98	– .07
1776									
January	1.78	1.97	+ .19	1.53	1.40	– .13	1.05	0.99	– .06
February	1.79	1.97	+ .18	1.56	1.40	– .16	1.07	1.00	– .07
March	1.81	1.99	+ .18	1.58	1.41	– .17	1.09	0.99	– .10
April	1.86	2.02	+ .16	1.59	1.43	– .16	1.10	1.02	– .08
May	1.84	2.02	+ .18	1.59	1.44	– .15	1.11	1.03	– .08
June	1.80	1.81	+ .01	1.60	1.44	– .16	1.12	1.02	– .10
July	1.73	1.52	– .21	1.63	1.44	– .19	1.13	1.00	– .13
August	1.74	1.41	– .33	1.63	1.42	– .21	1.13	0.99	– .14
September	1.72	1.38	– .34	1.60	1.39	– .21	1.07	0.96	– .11
October	1.80	—	—	1.61	—	—	1.09	—	—
November	1.80	—	—	1.56	—	—	1.06	—	—
December	1.80	1.44	– .36	1.54	1.34	– .20	1.06	0.91	– .15

[a] Months are solar. [b] Actual minus predicted price.

In Table 2.5 the data for the latter part of the 1761–63 flood crisis are presented. According to documentary evidence, this flood affected 53 counties in the Hai River Basin. By the beginning of 1762, prices were considerably higher than normal for all three grains. With the exception of a brief dip in June 1762, wheat prices kept climbing, reaching a level about 0.21 tael above normal in March–April 1763, after which prices began to come down, reaching their normal levels by the end of the year. Millet was the most severely affected of all the grains. Its price kept climbing until winter 1762–63, when it was more than 0.60 above normal. Its prices remained high during the year. Sorghum prices also reached a level of about 0.40–0.46 above their predicted prices in January–April 1763.

As both Table 2.5 and Figure 2.3 show, this flood marked one of the few times in the Qing period when the price of millet actually exceeded the price of wheat. In an extensive flood, property is damaged and recovery may take a longer time than after a drought. The data in this case certainly show a greater impact and a much slower recovery than do the data in the two cases involving drought. These results suggest a hypothesis for future investigation, namely, that floods in the Qing period had a more pronounced effect on prices than droughts did.

On the whole, however, these three cases show that the impact of crises in the eighteenth century was relatively moderate, especially in comparison with the staggering price increases of other well-documented world famines, or even late-nineteenth- or twentieth-century famines in China. According to Andrew B. Appleby, grain prices in French subsistence crises of the seventeenth and early eighteenth centuries rose to three or four times their normal levels.[31] In Zhili, in the eighteenth century at least, prices were not generally affected more than 10–20 percent; prices rose just over 40 percent for millet in 1762–63, the worst case seen so far.

Appleby also argues that the English mixed farming system, with animal husbandry and multiple grains, worked to minimize the effects of shortages because people could choose to eat inferior grains, usually reserved for livestock, instead of wheat, the preferred grain—eating down the food chain, so to speak. In Zhili the grain prices maintained a separation from each other, except in the 1761–63 flood, when millet prices reached and then exceeded those of wheat. Separation of prices suggests either that the markets were indeed separate, and there was little substitutability in crisis times, or else that there really was not a crisis, because there was no need for substitution. In a real crisis people become unable, or unwilling, to pay the exorbitant price of an expensive grain and therefore substitute an inferior grain, which in turn drives up the price of the second grain. Consequently, the separation

31. Andrew B. Appleby, "Grain Prices and Subsistence Crises in England and France, 1590–1740," *Journal of Economic History* 39, no. 4 (Dec. 1979):865–86.

TABLE 2.5. Grain Prices during the Last Years of the 1761–1763 Flood in Zhili Province (Excluding Baoding) (in taels per *shi*)

Year and Month[a]	*Wheat Price*			*Millet Price*			*Sorghum Price*		
	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]	Predicted	Actual	Residual[b]
1762									
January	1.70	1.89	+ .19	1.45	1.85	+ .40	0.98	1.18	+ .20
February	1.71	1.89	+ .18	1.48	1.85	+ .37	1.00	1.18	+ .18
March	1.73	1.89	+ .16	1.50	1.87	+ .37	1.03	1.22	+ .19
April	1.77	1.91	+ .14	1.51	1.85	+ .34	1.04	1.22	+ .18
May	1.76	1.86	+ .10	1.51	1.83	+ .32	1.05	1.23	+ .18
June	1.72	1.75	+ .03	1.52	1.84	+ .32	1.06	1.24	+ .18
July	1.65	—	—	1.54	—	—	1.07	—	—
August	1.66	—	—	1.54	—	—	1.06	—	—
September	1.64	1.75	+ .11	1.51	1.89	+ .38	1.01	1.22	+ .21
October	1.72	1.80	+ .08	1.52	1.92	+ .40	1.02	1.26	+ .24
November	1.72	1.85	+ .13	1.48	2.01	+ .53	0.99	1.33	+ .34
December	1.72	1.88	+ .16	1.45	2.06	+ .61	0.99	1.35	+ .36
1763									
January	1.70	1.89	+ .19	1.45	2.08	+ .63	0.99	1.39	+ .40
February	1.72	1.92	+ .20	1.48	2.10	+ .62	1.01	1.44	+ .43
March	1.74	1.95	+ .21	1.50	2.12	+ .62	1.04	1.47	+ .43
April	1.78	1.99	+ .21	1.51	2.14	+ .63	1.05	1.51	+ .46
May	1.77	—	—	1.52	—	—	1.05	—	—
June	1.73	—	—	1.52	—	—	1.06	—	—
July	1.65	1.76	+ .11	1.55	2.09	+ .54	1.07	1.43	+ .36
August	1.66	1.75	+ .09	1.55	2.04	+ .49	1.07	1.40	+ .33
September	1.65	1.74	+ .09	1.52	1.97	+ .45	1.01	1.30	+ .29
October	1.73	1.74	+ .01	1.53	1.90	+ .37	1.03	1.24	+ .21
November	1.72	1.74	+ .02	1.48	1.86	+ .38	1.00	1.22	+ .22
December	1.73	1.75	+ .02	1.46	1.84	+ .38	1.00	1.20	+ .20

[a] Months are solar. [b] Actual minus predicted price.

of prices (their nonconvergence) in 1743–44 and 1775–76 suggests that there was no real crisis in those two instances, while the convergence of millet and wheat prices in 1762–63 suggests that there was a real crisis in that situation. Again, this idea, like others in this paper, is advanced as a hypothesis that must be tested, particularly with prefectural data that will focus on the particular parts of the province affected in a particular crisis.

REGIONAL VARIATION

A central question in the study of these grain prices is the extent to which they varied within the province. In a well-developed market system, the correlation of prefectural prices ought to have been high, and price variation ought to have been low. Price variation within the province should also tell us something about the impact of crises. In a well-developed market system, the impact of natural disasters ought to have been cushioned, since grain would have been able to flow from unaffected regions to the affected ones. Of course, the same effects—strong price correlations and low price variation—might also have been achieved if the granary system was highly effective in its functions of price stabilization and famine relief or if the entire province had identical weather and other environmental conditions.

In approaching the question of market integration, we first employed the statistical measure called the coefficient of variation. The coefficient of variation is the standard deviation divided by the mean, multiplied by 100. It is a measure of the extent to which prices varied among prefectures during a given period. If market integration increased over time, then the coefficient of variation should decline. If, on the other hand, markets deteriorated, then the coefficient of variation should increase. We calculated the coefficients of variation of prefectural prices for each year from 1738 to 1910 for which we had data, omitting Xuanhua and Chengde, which were in the northern sections of the province. Then we did a regression analysis of the coefficients of variation with year (T) and crisis year (C) as variables. The resulting regression coefficients for year were 0.018, 0.041, and 0.013 for wheat, millet, and sorghum respectively (with t-values of 3.8, 7.8, and 2.6). In other words, the coefficients of variation for all three grains increased over time, and millet prices experienced significantly greater increases in regional variation than the other two grains.

These results are contrary to the expectation that over time markets should have become more integrated; if so, the coefficient of variation should have decreased. They also draw attention to, and invite explanation for, the different price behavior of millet, which was the staple grain for most people and which might perhaps have been more sensitive to population growth and to crises.

In the same regression analysis, however, the regression coefficients for

TABLE 2.6 Grain Price Variation in Crisis and Noncrisis Years in Zhili Province (Excluding Xuanhua and Chengde), 1738–1910

Crop	*Price in Noncrisis Years (mean of values)*	*Price in Crisis Years (mean of values)*	*Difference in Mean Price*
Wheat			
Standard deviation (taels)	0.24	0.25	
Mean price (taels)	1.97	2.10	+ .13
Coefficient of variation[a]	12.11	11.55	
Millet			
Standard deviation (taels)	0.22	0.24	
Mean price (taels)	1.77	1.93	+ .16
Coefficient of variation[a]	11.97	11.88	
Sorghum			
Standard deviation (taels)	0.16	0.17	
Mean price (taels)	1.22	1.32	+ .10
Coefficient of variation[a]	12.93	12.71	

[a] (Standard deviation / mean) * 100. Computed from standard deviations and means having more than two decimal places.

crisis years were all negative, with *t*-values under −2.0. That crisis years would cause variation to decline seems counterintuitive. When the various components of the coefficient of variation are separated out, however, a more plausible picture emerges. As Table 2.6 shows, the coefficient of variation declines for crisis years only because the standard deviation does not increase as much as the mean price. In other words, the lower coefficient of variation for crisis years is more a reflection of a higher mean price, totally to be expected, than diminished variation among prefectural prices. The table not only shows that the standard deviation did not increase very significantly in crisis years but also shows that the increase in the mean price was greater for millet—0.16 taels on the average—than it was for wheat or sorghum—0.13 and 0.10 taels respectively.[32] On the whole, this analysis confirms the impressions derived from the earlier case studies in supporting the view that the impact of crises, both on the level of prices and on their variation across regions, was relatively limited.

As a second step, we used Pearson correlations to study regional integration. The correlation coefficients measure the relationship between grain

32. The careful reader may note that the differences between the mean prices of crisis and noncrisis years differ somewhat from the crisis variables presented in Table 2.2. They are, however, roughly of the same order of magnitude as the last set, representing "crop year, Baoding only." Once again, it should be emphasized that regression analysis cannot produce precise results.

prices in pairs of prefectures, with 1.0 being a perfect correlation. The comparison of annual prices for the 17 prefectures of the province revealed astonishingly high degrees of correlation for most pairs of prefectures, with the unsurprising exceptions of Xuanhua and Chengde prefectures. Pearson correlations for wheat prices were mostly over 0.70, sometimes over 0.90, often above 0.80. Similar generalizations can be made for millet and sorghum.

When correlations are calculated separately for eighteenth- and nineteenth-century prices, no clear trend can be confirmed. While wheat correlations between most pairs of prefectures seem to rise, for millet the picture is more mixed. Excluding Chengde and Xuanhua, correlations for the remaining 15 prefectures show that in 59 of 105 cases, correlations declined from the eighteenth to the nineteenth centuries, while in 46 cases they increased. This partly supports the picture presented by the study of coefficients of variation, and continues to make interesting the hypothesis that millet prices experienced greater spatial variation in the nineteenth century than the eighteenth century. Clearly, the next step in pursuing this question is to study the province on a region by region basis to see which regions shared this experience and which did not.

Since the correlation of prices themselves incorporates a similar time trend for all of the prefectures, it exaggerates the extent to which prices were actually correlated. Studying the first difference of these prices (the difference between the price in a given year and the price in the previous year) omits the common time element and provides a better measure of correlation. A preliminary analysis of annual price differences for the eighteenth century reveals that for wheat and millet about two thirds of the possible correlations between prefectures were 0.60 or over; for sorghum over 55 percent of the correlations were over 0.60. These results also suggest a reasonably high degree of correlation, but understanding their significance must await further work, and comparing them to nineteenth-century correlations must await a more complete set of nineteenth-century data.

Taken together, these preliminary attempts to study price variation in Zhili suggest a relatively high degree of integration within Zhili Province south of the Great Wall, but an integration that may have declined in some sections of the province, particularly in the case of millet, from the eighteenth to the nineteenth centuries. It should not be assumed, however, that integration was necessarily the result of a well-developed market system. The relative behavior of wheat and millet prices suggests that the market for wheat, a commercial product, may have been well developed and may have become more integrated in the nineteenth century. Millet, on the other hand, was the staple grain for ordinary people. In the eighteenth century, its apparent high degree of price correlation may have been due to the fact that the Zhili granaries predominantly stocked millet. With the decline of the granary system in the nineteenth century, price correlation may also have declined, because the eighteenth-century integration of prices was probably more a function of the granary system than of the market system. Until some estimate can be made of the output and supply of each of these grains in the Qing period, and until the nineteenth-century data are more complete, these hypotheses must await testing.

CONCLUSIONS

While indicating directions for future work, this preliminary study of grain prices in Zhili Province during the Qing period also permits us to draw certain tentative conclusions. In the most general terms, this study suggests, first, that there was a relatively low inflationary trend for the Qianlong through the Xuantong reign periods (1736–1911), particularly so when the last two decades are omitted. Second, although there were distinct seasonal patterns in grain prices, they were not great in magnitude, and were offset by the multicrop system, particularly by the planting of winter wheat.

Third, crises were seen in several contexts to have been moderate in their impact, at least in the eighteenth century. Regression analysis showed the impact of crises to have been relatively contained. Crises caused the mean price of grain to rise somewhat but did not cause a very great increase in regional variation. The three eighteenth-century case studies confirm these general impressions. In fact, while these periods were deemed crises in administrative terms, and while they were triggered by natural crises, perhaps they were not really food crises if food crises are defined as periods of abnormally high food prices.[33]

Fourth, the multicrop system appears to have been a significant factor in mitigating the effect of crises, particularly because of the different seasonal patterns of the crops. Multicropping certainly helped to offset the disadvantages presented by weather and geography, and has perhaps been overlooked in previous discussions. Appleby's study concludes that in England and France "the evidence suggests that a symmetrical price structure and subsistence crises went hand in hand. When all grains were costly at the same time, food shortage had an impact on both mortality and fertility; when one or another grain remained cheap, the demographic aftereffects were absent."[34] It is too soon to conclude that such a generalization could be made for Zhili, but certainly this suggests a framework for future investigation. For North China, Buck observed in the 1920s and 1930s that farmers sold the higher-priced grain and ate inferior grain. Farmers in the wheat

33. I have explored these issues more fully in "Using Grain Prices to Measure Food Crises: Chihli Province in the Mid-Ch'ing Period," *The Second Conference on Modern Chinese Economic History* (Taibei, 1989), II, pp. 467–509.

34. Appleby, "Grain Prices," p. 882.

region, he said, sold half the wheat they grew, and purchased inferior grain, an estimated one quarter of their food needs, from the market.[35]

The long-term behavior of millet prices seems to be the outcome of either deteriorating economic conditions (population pressure, etc.) or the diminished role of government intervention in the grain market or, more likely, both. The greater volatility of millet in some crises, its increasing coefficients of variation over time, and its lower price correlations in some regions in the nineteenth century all suggest certain long-term changes in its role in the food supply of Zhili. On the other hand, price analysis suggests that the role of sorghum did not experience a similar change. Francesca Bray has suggested that sorghum probably became more important in the nineteenth century with increasing population pressure.[36] However, the long-term trends shown in Figure 2.4 do not support this view, since the price of sorghum continued to remain a constant percentage of the price of wheat and always remained separate from that of the higher-priced millet.

Finally, future work may confirm that prices throughout the region, with the exception of the two outlying prefectures, were remarkably well correlated, suggesting the powerful interaction of granaries and markets.

To understand better the nature of these secular changes, we need to have more complete price data for the nineteenth century and better weather data. This will permit us to understand more about long-term trends over both centuries. We also need to know more about the interaction between the grain tribute system, the granaries, and the grain markets in the determination of prices. Only then will it be possible to grasp why a region so indifferently and curiously endowed by nature could play such a large political role over centuries of history.

35. Buck, *Land Utilization in China*, 1:416.

36. Francesca Bray, *Agriculture*, vol. 6, pt. 2, of Joseph Needham, ed., *Science and Civilization in China* (Cambridge, 1984), pp. 434, 464, 451–52.